Carotid Artery Stenosis:
Diagnostic Imaging and Minimally Invasive Treatment

Samuel Ng, Harvard Medical School Year III
Gillian Lieberman, MD
Objectives

1. To review carotid artery stenosis and its clinical implications

2. To present the advantages and disadvantages of the different modalities used to image and to characterize carotid artery stenosis

3. To introduce percutaneous transluminal stent-angioplasty (PTCA) as a minimally invasive treatment option for carotid artery stenosis
Carotid Artery Stenosis

- Carotid Artery Stenosis rapidly becomes symptomatic when it occludes 75% of the vessel diameter.

- Severe stenosis can result in transient ischemic attacks (TIA)s either through global ischemia or an embolic process.

- The most serious consequence of carotid artery stenosis is cerebrovascular accident.

  The mortality from the acute attack is 20 percent.
  Survival after five years is 50 percent.
  Approximately 25 percent of the survivors will have a second event, leading to death in one-half*.

- The incidence of stroke in patients with greater than 75% carotid artery stenosis is 5.5% compared to an overall rate incidence of 1.7% per year*.

- Due to the significant morbidity and mortality associated with cerebrovascular accident, accurate diagnosis and effective treatment of carotid artery stenosis is indicated.

*Chambers, Messinrt
A Short Differential for Carotid Artery Stenosis

Atherosclerosis

**Inflammatory:**
- Takayasu’s Arteritis
- Systemic Lupus Erythematosus
- Polyarteritis Nodosa

**Non-Inflammatory:**
- Fibromuscular Dysplasia
- Hemangioma
Most Common sites for extracranial cerebrovascular stenosis are the proximal internal carotid artery (ICA) > proximal vertebral artery distal ICA > proximal common carotid (CC)*

*Hass
Our Patient

A 48 year old female with a history of hypertension and a 10 pack year history of smoking presented for radiologic work-up after experiencing a transient ischemic attack (TIA).

One week before admission, she felt numbness on the right side of her face as well in her upper and lower right extremities. One month prior to that incident, she experienced an ‘ink-blot’ like disturbance of her visual field which lasted three minutes.

Upon admission, head CT showed no signs of hemorrhage or infarction.

Later, physical examination revealed a left carotid bruit.
Standard Diagnostic Work-up

Carotid Duplex Ultrasound (CDUS)
Magnetic Resonance Angiography (MRA)
Digital Subtraction Angiography (DSA)
Our patient did not undergo carotid ultrasound but our discussion includes it for completeness:

**CDUS**

CDUS uses B-mode ultrasound imaging and Doppler ultrasound to detect focal increases in blood flow velocity.

**Advantages:**
- Noninvasive, Safe
- Relatively inexpensive
- 94 percent sensitive, 89 percent specific for detecting significant carotid artery stenosis*

**Disadvantages:**
- Highly operator dependent
- Less precise in detecting stenosis of less than 50 percent*
- Hairline residual lumens can be missed
- Only the cervical portion of the carotid artery can be examined

*Turnipseed, Carroll
Classic CDUS plaque imaging

- Normal Right CCA
- Right ICA plaque
Normal Doppler Waveforms

ECA: Flow rises sharply during systole and falls rapidly in diastole, approaching zero or transiently reversing direction

ICA: Large quantity of forward flow continues through diastole. The systolic peak is generally wide

CCA: A mix between the two, but CCA generally follows ICA pattern
CDUS Doppler Spectra

- Normal Right ICA
- Stenotic Right ICA

- Increased Peak Systolic Velocity
- Increased Peak Diastolic Velocity
- Spectral Broadening
Our Patient received an MRA:

MRA produces a good three dimensional image of the carotid bifurcation with good sensitivity for detecting high grade carotid stenosis.

**Advantages:**
Noninvasive
Less operator variability than CDUS
Ability to visualize the proximal CC, the distal extracranial ICA, and the intracranial vessels
Avoidance of iodinated contrast material
Avoidance of Ionizing Radiation

**Disadvantages:**
Difficult to define vascular anatomy in the presence of complex, turbulent, or minimal flow
Overestimates degree of carotid stenosis
Up to 17 percent of MRA studies are incomplete due to patient movement*

*Sitzer
This study demonstrates severe stenosis with post-stenotic dilatation in the distal ICA.
Our Patient then underwent DSA:

DSA is the gold standard for carotid artery imaging. It requires catheterization and two unimpeded views.

**Advantages:**
Permits Evaluation of the entire carotid artery system
Tandem atherosclerotic disease
Plaque morphology
Collateral circulation which may affect management

**Disadvantages:**
Invasive with associated risks of morbidity and mortality
Risk of all neurologic complications is 4 percent
Risk of serious neurologic complications is 1 percent*
High Cost
Exposure to Ionizing Radiation
Iodinated contrast is used
Our Patient: Digital Subtraction Angiographic image of the left carotid arteries

Findings compatible with...

Focal nodules of vessel thickening
ICA stenosis
Post-Stenotic Dilatation

CC: Common Carotid  EC: External Carotid  IC: Internal Carotid
Fibromuscular Dysplasia (FMD)

- Non-atherosclerotic, non-inflammatory vascular disease affecting small and medium-sized arteries
- FMD is the underlying cause of 2-5 percent of the hypertensive population*
- Cause of FMD remains unknown
- Four histologic subtypes:

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<thead>
<tr>
<th>Medial Fibromuscular Dysplasia</th>
<th>Intimal Hyperplasia (1-5%)</th>
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<tbody>
<tr>
<td>(70-95% of all FMD)</td>
<td>Circumferential of eccentric accumulation of fibrous tissue in the intima</td>
</tr>
<tr>
<td>Classic “String of Beads” image seen with angiography</td>
<td>Non inflammatory, no lipid accumulation (as opposed to atherosclerosis)</td>
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<tr>
<td>Thickened Fibromuscular ridges alternating with thinning and widening of the vessel wall.</td>
<td>Perimedial subtype primarily affects young women</td>
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<td>Perimedial subtype primarily affects young women</td>
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<table>
<thead>
<tr>
<th>Medial Hyperplasia (&lt;5% all FMD)</th>
<th>Periadventitial fibroplasia (rare)</th>
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<tr>
<td>Focal concentric stenosis caused by excessive medial smooth muscle proliferation</td>
<td>Fibroplasia with collagen encompasses the adventitia and extends into the surrounding tissue</td>
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<tr>
<td>Involves middle or distal part of the artery</td>
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*Luscher
Our Patient showed Abnormal Cerebral Perfusion from the Left ICA

These findings indicate a functional decrease in left ICA perfusion.

Interventional treatment was therefore performed.
Percutaneous transluminal catheter stent-angioplasty

A minimally invasive treatment option for carotid artery stenosis that has not yet been approved by the FDA and thus is still considered experimental

Considerations for procedure (vs. Carotid Endarterectomy)

- Prior neck irradiation procedure
- Previous surgery
- Intimal hyperplasia
- Tandem Lesion
- Severe Comorbid disease

Because FMD is a non-atherosclerotic process of stenoses, PTCA is indicated.
Percutaneous transluminal catheter stent-angioplasty

PTCA vs. Carotid Endarterectomy

Combined results from the large scale, well controlled North American Symptomatic Carotid Endarterectomy Trial (NASCET) and the European Carotid Surgery Trial (ECST) demonstrate a notable benefit for Carotid Endarterectomy vs. medical management in patients with symptomatic carotid artery stenosis > 70% luminal diameter*

Several studies claim that PTCA has similar efficacy to carotid endarterectomy. One retrospective study comparing the two found increased minor stroke among PTCA (6.6% vs. 0.6%) but a decreased rate of major stroke or death compared to the surgical cohort (2.8% vs. 4.2%)#

The large scale Carotid Revascularization Endarterectomy versus Stent (CREST) trial is underway which will compare the two procedures, but the findings are still years away
Flow restoration following PTCA in our patient

Flow through the previously stenotic area is now normal

“Wash-out” defect no longer present in ACA
Maxillary artery branches now demonstrate delayed filling
References


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